

# OLEDWorks LLC

Manufacturing OLED Lighting Panels

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The need for low cost manufacturing equipment for panels, components and luminaires to enable a U.S. OLED SSL manufacturing industry

# OLED Status vs. DOE Roadmap



## Current Products (2012)

- **Price: \$5,000-20,000/m<sup>2</sup>**
- **Price: \$500-2,000/klm**
- **Manufacturers:**  
LG, Panasonic, Blackbody, Osram, Lumiotec, & Philips
- **Panel Efficacy: 25-60 lm/W**
- **L70 @3000 nits: 1-15,000 hr**

## DOE Roadmap for 2012

- **Cost: \$270/m<sup>2</sup>**
- **Cost: \$45/klm**
- **Manufacturers:**  
**At Least 1 US Manufacturer?**
- **Panel Efficacy: 86 lm/W**
- **L70 @3000 nits: 11,000 hr**

- **Grow market by providing sufficient performance at a reasonable cost while enabling unique products.**
- **Mid to high end of current performance is good enough for initial products, but price is much too high.**
- **Current manufacturers are using equipment and processes that will not be able to meet current or future cost targets.**
- **DOE must support novel low cost manufacturing equipment and methods.**

# LED “Panels” Status



## Current Products (2012)

- **Price: \$400-800/m<sup>2</sup>**
  - **Price: \$40-80/klm**
  - **Manufacturers: Many**
  - **Panel Efficacy: 45-70 lm/W**
  - **L70 @3000 nits: 50,000 hr**
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- **LED price and performance is currently much more competitive with traditional lighting than OLED**
  - **Despite LED's lead, many lighting designers and luminaire manufacturers believe there is a place for OLED in the lighting market**
  - **Long term OLED price and performance must be competitive with LED**
  - **DOE can enable a U.S. OLED SSL manufacturing industry by supporting the low volume early phase of the market**

# How Do We Get Cost Down?

Component	Requirement	DOE 2012 Targets	Estimated 2012 Actual*
Equipment (Entire Line)	\$100 capital/m <sup>2</sup> /yr \$25M total cost \$20/m <sup>2</sup>	\$5,000 capital/m <sup>2</sup> /yr \$60M total cost \$1000/m <sup>2</sup>	\$1,000/m <sup>2</sup>
OLED Materials	\$10/m <sup>2</sup>	\$40/m <sup>2</sup>	\$500/m <sup>2</sup>
Other Materials	Int. Sub: \$15/m <sup>2</sup> Encapsulation: \$10/m <sup>2</sup> Other: \$5/m <sup>2</sup>	\$60/m <sup>2</sup> \$20/m <sup>2</sup> \$15/m <sup>2</sup>	\$400/m <sup>2</sup> \$400/m <sup>2</sup> \$400/m <sup>2</sup>
Labor	\$5/m <sup>2</sup>	\$400/m <sup>2</sup>	\$1000/m <sup>2</sup>

\*Adjusted for DOE roadmap assumptions for yield, substrate utilization and uptime

- Highest priority is low cost/high throughput/highly automated equipment for every step of the manufacturing process (highest cost step is OLED stack deposition).
- Second highest priority is low cost “other materials” which also requires low cost/high throughput/highly automated equipment .

# OLED Manufacturing Example Issue



- Current manufacturers are using Gen 2 scale lines
  - ~ 2 min TAC Time
  - ~ 20% maximum materials utilization
  - DOE estimated capacity is ~ 12,000m<sup>2</sup>/yr
  - ~ \$60M capital investment (\$5,000 capital/m<sup>2</sup>/yr)
  - Depreciation is ~ \$1,000/m<sup>2</sup>
- Scaling to 1 min TACT on Gen 5 for cost reduction will:
  - Require 8x higher evaporation and deposition rates
  - Require 8x more material in source and at temperature for 7-14 days
  - Require 2-4x improvement in materials utilization
  - Require 50x reduction in ratio of capital investment to throughput (\$100 capital/m<sup>2</sup>/yr)
- **A novel solution to reducing the ratio of capital investment to throughput while increasing total capacity is needed.**

# Proposed Priority Tasks



- M.01 Manufacturing equipment for high speed, low cost, uniform deposition of state of the art OLED structures and layers (OLED stack deposition)
  - Enable novel, low cost manufacturing
  - Enable profitable market entry for panel makers and luminaire manufacturers
  - Cannot ignore depreciation and labor
  - Must be scalable and profitable from low early volumes to high future volumes
  - Must be different than what Asia and Europe are doing
- M.03 Manufacturing of low cost integrated substrates and encapsulation materials
  - Enable novel, low cost supply of integrated substrates and encapsulation materials
  - Must be different than what suppliers to the display industry are doing

# How DOE Can Help?



- Fund novel low cost/high throughput vacuum deposition equipment
  - **LOWER ENTRY BARRIER:** More US companies can participate in panel manufacturing, odds of success increases, longer term need for government support decreases
  - **SURVIVE VALLEY OF DEATH:** Cost competitive and profitable early products will provide internal funding required for further performance improvements
  - **FASTER MARKET PENETRATION:** Faster market growth, faster energy savings and faster performance improvement
- Fund low cost integrated substrates and encapsulation equipment
  - **ENABLE EARLY ENTRY:** Decreases risk of installing equipment for early low volume market
  - **REDUCE PRODUCT COST STRUCTURE:** Lighting requires 10x cost reduction vs. displays

**Novel approaches are possible!**

**Novel approaches have been proposed!**

**Fund these novel approaches appropriately for success!**